AFRL-SR-AR-TR-09-0374

REPORT DOCUMENTATION PAGE

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06-12-2009	Final Performance Report	15 July 2009 – 30 Nov. 2009

4. TITLE AND SUBTITLE
Workshop on Aerospace Materials for Extreme Environments

5a. CONTRACT NUMBER
FA~~9550~~-09-1-0564

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
William G. Fahrenholtz, Gregory E. Hilmas, Erica Corral, and Laura Riegel

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Missouri University of Science and Technology
Dept. of Materials Sci & Eng
222 McNutt Hall
Rolla, MO 65409

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Office of
Scientific Research
875 North Randolph ST.
Suite 325, Room 3112
Arlington, VA 22203 DR FULLER/RSA

10. SPONSOR/MONITOR'S ACRONYM(S)
AFOSR/NA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution of this document is not restricted

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report summarizes the activities that were conducted as part of the AFOSR Workshop on Aerospace Materials for Extreme Environments that was held August 3-5, 2009 in Clayton (St. Louis), MO. The workshop brought together ~80 participants from universities, government laboratories, and companies from around the world. The agenda included 28 invited presentations and 23 additional posters on the current status and latest research results related to the fundamental science of materials for possible application in hypersonic aerospace vehicles. This report includes a summary of workshop activities, a list of attendees, a copy of the foreword for the special issue of the Journal of the European Ceramic Society, and a list of presentation and poster titles. In addition, a CD will be submitted to the program manager with copies of presentations from the workshop.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
U	U	U	UU		

Table of Contents

Table of Contents 1
Executive Summary 2
Objectives 3
Status of Effort 3
Accomplishments/New Findings 3
Personnel Supported 3
Publications/Presentations 4
Interactions/Transitions 4
Discoveries, Inventions, and Patent Disclosures 5
Awards 5
Appendix A: Attendance List 6
Appendix B: Workshop Schedule 8
Appendix C: Foreword for Journal of the European Ceramic Society 10
Appendix D: List of Manuscripts Submitted for Publication 11

Executive Summary

The Workshop on Aerospace Materials for Extreme Environments was held on August 3-5, 2009 in Clayton (St. Louis), MO. The workshop was attended by nearly 80 researchers from universities, government laboratories, and companies from around the world who investigate fundamental aspects of materials that may someday find use in advanced aerospace vehicles. The workshop consisted of ~25 invited presentations and ~20 additional poster presentations from leading researchers in this area from around the world. In addition to the current research leaders in this field, ~30 early-career professionals participated in the meeting in an effort to help attract a future generation of researchers to this challenging research field. Manuscripts based on workshop presentations will be published in an issue of the Journal of the European Ceramic Society focused on materials for extreme environments. Publication is planned in the late spring or early summer of 2010.

Objectives

The objective of this project was to organize and conduct a workshop focused on fundamental research related to ultra-high temperature structural materials that are candidates for use in hypersonic aerospace vehicles. The goal was to have participation from the leading researchers in the world who investigate ultra-high temperature materials for aerospace applications.

In addition to the primary goal of organizing the workshop, a secondary goal of the workshop was to help broaden participation in research related to ultra-high temperature materials for aerospace applications.

Status of Effort

The term of this project was from July 15, 2009 to November 30, 2009. As part of the project, The Workshop on Aerospace Materials for Extreme Environments was held on August 3-5, 2009 in St. Louis, MO.

The workshop was successful in attracting the leading researchers from the U.S. and the world who focus on ultra-high temperature materials for aerospace applications. The workshop was attended by nearly 80 researchers from universities, government research laboratories, and companies from the U.S., China, Italy, France, England, and the Ukraine.

The workshop was also successful in attracting participation from graduate students and early-career professionals who are the potential "next generation" of leaders in this field. The workshop was attended by ~30 early-career professionals and graduate students in an effort to foster their continued involvement with the community of researchers who investigate ultra-high temperature materials. A complete listing of attendees and their affiliations is provided in Appendix A.

Accomplishments/New Findings

The workshop included sessions on "Mechanical and Physical Properties," "Synthesis, Processing, and Structure," and "Oxidation and Environmental Response." A full workshop schedule is provided in Appendix B. The advancements in fundamental understanding of UHTCs related to these topics will be published as part of a focused section in an upcoming issue of the Journal of the European Ceramic Society.

Personnel Supported

Funds from the workshop were used to support the salary of a senior secretary in the Materials Science and Engineering Department at Missouri S&T (Table 1).

Table 1. Personnel supported on AFOSR contract FA2386-09-1-0564.

Name	Title/Role	Level of Support
Amy Moore	Senior Secretary	20 hours

In addition to salary for the senior secretary, funds from the workshop were used to provide travel support for invited speakers from foreign countries. Travel support was provided for several graduate students and select early-career professionals who participated in the workshop (Tables 2 and 3). The Asian Office of Aerospace Research and Development (AOARD, primary contact Dr. Kumar Jata) also provided funding that was used to partially support travel for the Chinese scientists.

Table 2. Invited foreign speakers who received travel support from AFOSR contract FA2386-09-1-0564.

Name	Title of Presentation/Other Contribution	Country
Laura Silvestroni	Toughened ZrB_2- Based Ceramics with Addition of SiC Whiskers or Chopped Fibres	Italy
Velerii Kotenko	New Methods of Strength Determination for Brittle Materials	Ukraine
Yanchun Zhou*	New Zr(Hf)-Al(Si)-C Ceramics and Their Composites for Ultrahigh Temperature Applications	China
Bill Lee	Laser Modified Microstructures in ZrB_2, ZrB_2-SiC, and ZrC	England
Oleg Grygoriev	High-Temperature Ceramic Matrix Composites of MeB_2-$MeSi_2$ Systems–Structure and Some Properties	Ukraine
Alina Ievdokymova	ZrB_{12}-Based Tool Materials for Titanium Alloys Machining	Ukraine
Volodymyr Filipov	Influence of Lattice Parameter Mismatch between Fibers and Matrix on Structure and Properties of Directionally Solidified LaB_6 - $(Ti,Zr)B_2$ Composites	Ukraine
Frederic Monteverde	Plasma Wind Tunnel Testing and Numerical Simulation of Ultra-High Temperature Ceramics for Space Applications	Italy
Xinghong Zhang*	Preparation, Toughening/Strengthening and Oxidation of ZrB_2-Based Ultra-High Temperature Ceramic Composites	China
Guo-Jun Zhang*	Microstructure Tailoring and Material Property Improvement of UHTCs	China

* Partial support for this participant provided through AOARD.

Publications/Presentations

Manuscripts based on presentations at the workshop will be published in a focused section of an upcoming issue of the Journal of the European Ceramic Society that is scheduled for publication in the late spring or early summer of 2010. The foreword drafted for the special issue is included as Appendix C while a list of manuscripts that have been submitted for publication is included as Appendix D.

Interactions/Transitions

The workshop provided a forum for informal interactions among researchers from academia, government research laboratories, and companies from the U.S. and abroad. The workshop provided a formal forum for researchers to present results to other leading researchers in this field, representatives from U.S. Department of Defense research laboratories, and companies that may utilize these materials in future aerospace vehicles. In addition, the participants had ample time for informal interactions during coffee breaks, lunches, and the afternoon reception in the Prologue Room at Boeing-St. Louis.

Table 3. Graduate students and early-career professionals who received travel support from AFOSR contract FA2386-09-1-0564.

Name	Institution	Poster Title
Xiao Ye*	Univ of. Mass.	Non-Contact Measurement of Creep Deformation
Luning Zhang†	SRI International	Thermal and Electrical Property Characterization of Diboride-Based UHTC Materials: Effects of Microstructure and Composition
Kalvis Terauds*	Univ. of Colorado	Piezoresistivity of Polymer Derived Ceramics at Elevated Temperatures
Jeremy Watts*	Missouri S&T	Stress Measurement in ZrB_2/SiC Composites using Raman Spectroscopy and Neutron Diffraction
Manuel Acosta*	Purdue	Design and Manufacture of Ultra-High Temperature Ceramics with Oriented Strengthening and Toughening Phases (CERASGEL)
Harlan Brown-Shaklee*	Missouri S&T	Reaction Sintering and Characterization of ZrB_2-SiC Composites
Matt Thompson*	Missouri S&T	Densification and Microstructure of ZrB_2
David Lipke*	Georgia Tech	Reaction Syntheses of Discontinuous Tungsten Carbide Fibers
Luke Walker*	Univ. of Arizona	
Fei Ping† & Gregg Van Laningham*	Georgia Tech	Oxidation Resistance of of ZrB_2-Based Multi-phase Microstructures at Temperatures above 1500°C
Gaurav Mohanty* & Prasanna Balachandran*	Iowa State University	Informatics for Nanomechanical Characterization and Chemical Modeling of High Temperature Materials
Kathy Sevener†	Valparaiso Univ.	A Comparison of the Oxidation Behavior of Hot Pressed and Spark Plasma Sintered HfB_2-SiC
P. Sarin†	Univ. of Illinois	In-situ Studies of Oxidation of ZrB_2 and ZrB_2-SiC Composites at High Temperatures

* Graduate Student
† Early career professional

Discoveries, Inventions, and Patent Disclosures

None directly associated with this project.

Awards

None directly associated with this project.

Appendix A: Attendance List

	First Name	Last Name	Affiliation	Email Address
1	Manuel	Acosta	Purdue University	acosta@purduc.cdu
2	Tom	Augustine	Boeing	tom.augustinc@bocing.com
3	Prasanna	Balachandran	Iowa State University	
4	Donna	Ballard	AFRL	donna.ballard@wpafb.af.mil
5	Marie-Helene	Berger	Mines-Paris Tech	marie-helene.berger@mines-paristech.fr
6	Arturo	Bronson	University of Texas-El Paso	abronson@utep.cdu
7	Harlan	Brown-Shaklee	Missouri Univ. of Sci. and Tech.	hjb4mb@mst.cdu
8	Jack	Chessa	University of Texas-El Paso	jfchessa@utep.edu
9	Michael	Cinibulk	Air Force Research Laboratory	Michael.Cinibulk@WPAFB.AF.MIL
10	Erica	Corral	University of Arizona	clcorral@cmail.arizona.cdu
11	Dan	Driemeyer	Boeing	dan.driemeyer@boeing.com
12	Tom	Eason	Air Force Research Laboratory	Thomas.eason@wpafb.af.mil
13	Bill	Fahrenholtz	Missouri Univ. of Sci. and Tech.	billf@mst.cdu
14	Volodymyr	Filipov	IPMS / Ukraine	filipov@ipms.kiev.ua
15	Doug	Fletcher	University of Vermont	douglas.fletcher@uvm.cdu
16	Joan	Fuller	AFOSR	joan.fuller@afosr.af.mil
17	David	Furdek	Boeing Research and Technology	david.m.furdek@bocing.com
18	Matt	Gasch	NASA Ames Research Center	Matthew.J.Gasch@nasa.gov
19	Oleg	Grygoriev	IPMS / Ukraine	oleggrig@ipms.kiev.ua
20	John	Halloran	University of Michigan	peterjon@umich.cdu
21	Mark	Haney	Air Force Research Laboratory	Mark.Haney@wpafb.af.mil
22	Greg	Hilmas	Missouri Univ. of Sci. and Tech.	ghilmas@mst.cdu
23	Robert	Hyers	R. Hyers and Associates	hyers@ecs.umass.cdu
24	Alina	Ievdokymova	IPMS / Ukraine	ievdokimova@ipms.kiev.ua
25	Kumar	Jata	AOARD/AFOSR	kumar.jata@aoard.af.mil
26	Sylvia	Johnson	NASA Ames Research Center	sylvia.m.johnson@nasa.gov
27	Suneel	Kodambaka	University of California-Los Angeles	suneel.kodambaka@gmail.com
28	Valerii	Kotenko	IPMS / Ukraine	valeriykotenko@gmail.com
29	Trudy	Kriven	Univ. of Illinios at Urbana-Champaign	kriven@illinois.cdu
30	Stan	Lawton	Boeing	stan.lawton@boeing.com
31	William	Lee	Imperial College	w.e.lee@imperial.ac.uk
32	David	Lipke	Georgia Institute of Technology	DLipke@gatech.cdu
33	Jian	Luo	Clemson University	JIANLUO@exchange.clemson.cdu
34	Jochen	Marschall	SRI International	jochen.marschall@sri.com
35	David	Marshall	Teledyne Scientific Company	dmarshall@tcledync.com
36	Gaurav	Mohanty	Iowa State University	
37	Frederic	Monteverde	CNR-ISTEC	frederic.monteverdc@istec.cnr.it
38	Greg	Morscher	NASA Glenn Research Center	gregory.n.morscher@nasa.gov
39	Eric	Neuman	Missouri Univ. of Sci. and Tech.	ewnc46@mst.cdu
40	QuynhGiao	Nguyen	NASA Glenn Research Center	quynhgiao.n.nguyen@nasa.gov
41	Dusan	Pejakovic	SRI International	dusan.pejakovic@sri.com

List continued on next page

Attendance List (Continued)

42	Fei	Ping	Georgia Institute of Technology	fei.peng@gatech.edu
43	Rishi	Raj	University of Colorado at Boulder	rishi.raj@colorado.edu
44	Krishna	Rajan	Iowa State University	krajan@iastate.edu
45	Laura	Riegel	Boeing	Laura.Riegel@boeing.com
46	Bridget	Rogers	Vanderbilt University	bridget.rogers@vanderbilt.edu
47	Wynn	Sanders	EOARD	wynn.sanders@london.af.mil
48	Ken	Sandhage	Georgia Institute of Technology	ken.sandhage@mse.gatech.edu
49	Pankaj	Sarin	Univ. of Illinios at Urbana-Champaign	p-sarin@illinois.edu
50	Ali	Sayir	NASA Glenn Research Center	ali.sayir-1@nasa.gov
51	Kathy	Sevener	Valparaiso University	kathleen.sevener@valpo.edu
52	Laura	Silvestroni	ISTEC	laura.silvestroni@istec.cnr.it
53	Robert	Speyer	Georgia Institute of Technology	robert.speyer@mse.gatech.edu
54	Lia	Stanciu	Purdue University	lstanciu@purdue.edu
55	Todd	Steyer	Boeing	todd.c.steyer@boeing.com
56	Inna	Talmy	Naval Surface Warfare Center	inna.talmy@navy.mil
57	Kalvis	Terauds	University of Colorado at Boulder	Kalvis.Terauds@Colorado.EDU
58	Matt	Thompson	Missouri Univ. of Sci. and Tech.	mjtwf8@mst.edu
59	Vikas	Tomar	Notre Dame University	vikas.tomar@nd.edu
60	Rodney	Trice	Purdue University	rtrice@ecn.purdue.edu
61	Michael	Uchic	AFRL/RXLMD	michael.uchic@wpafb.af.mil
62	Gregg	Vanlaninham	Georgia Institute of Technology	gregg@gatech.edu
63	Joost	Vlassak	Harvard University	vlassak@esag.deas.harvard.edu
64	John	Waldrop	Boeing	john.c.waldrop-iii@boeing.com
65	Luke	Walker	University of Arizona	lswalker@email.arizona.edu
66	Jeremy	Watts	Missouri Univ. of Sci. and Tech.	jwatts@mst.edu
67	Don	Weaver	AFRL/RXLM	donald.weaver@wpafb.af.mil
68	Ken	White	University of Houston	kwwhite@uh.edu
69	Eric	Wuchina	Office of Naval Research	eric.wuchina@navy.mil
70	Xiao	Ye	University of Massachusetts	xye@engin.umass.edu
71	Jeff	Youngblood	Purdue University	jpyoungb@purdue.edu
72	Guo-Jun	Zhang	Shanghai Insititue of Ceramics	gjzhang@mail.sic.ac.cn
73	Luning	Zhang	SRI International	luning.zhang@sri.com
74	Shi	Zhang	Missouri Univ. of Sci. and Tech.	scz@mst.edu
75	Xinghong	Zhang	Harbin Institute of Technology	zhangxh@hit.edu.cn
76	Yanchun	Zhou	Institute of Metals Resarch, China	yczhou@imr.ac.cn

Appendix B: Workshop Schedule

Monday August 3, 2009

Mechanical and Physical Properties

Time	Speaker	Title
1:00 pm	Joan Fuller	Welcome and workshop overview
1:15 pm	Laura Silvestroni	Toughened ZrB_2- Based Ceramics with Addition of SiC Whiskers or Chopped Fibres
1:45 pm	Greg Hilmas	Modeling and Measuring Residual Stresses in ZrB_2-SiC Ceramics
2:15 pm	Greg Morscher	Creep of SiC-SiC Composites
2:45 pm		Break
3:00 pm	Robert Hyers	Non-Contact Measurement of Creep in Ultra High Temperature Ceramics
3:30 pm	John Halloran	Electromagnetic Mechanical Apparatus for Non-Contact Mechanical Testing of Ultra High Temperature Ceramics
4:00 pm	Trudy Kriven	In situ Studies of High Temperature Phase Transformations in Oxide Ceramics
4:30 pm	Velerii Kotenko	New Methods of Strength Determination for Brittle Materials
5:00 pm		Poster Session
6:30 pm		Adjourn for the day

Tuesday August 4, 2009

Processing, Synthesis, and Structure

Time	Speaker	Title
8:00 am	Yanchun Zhou	New Zr(Hf)-Al(Si)-C Ceramics and Their Composites for Ultrahigh Temperature Applications
8:30 am	Bill Lee	Laser Modified Microstructures in ZrB_2, ZrB_2-SiC, and ZrC
9:00 am	Oleg Grygoriev	High-Temperature Ceramic Matrix Composites of MeB_2-$MeSi_2$ Systems–Structure and Some Properties
9:30 am	Ken Sandhage	Near Net Shape/Dimension Fabrication of Refractory, Erosion-Resistant Carbide/Refractory Metal Composites
10:00 am		Break
10:30 am	Rishi Raj	Ultrahigh Temperature Semiconductors Made from Polymer Derived Ceramics
11:00 am	Dusan Pejakovic	Carbon-Rich Hafnia Thin Films Synthesized by Pulsed Laser Deposition
11:30 -1:00		Lunch Break on your own
1:00 pm	Alina Ievdokymova	ZrB_{12}-Based Tool Materials for Titanium Alloys Machining
1:30 pm	Donna Ballard and Don Weaver	Processing of Thin Gage Platinum Group Metal- Modified Nickel-Based Super Alloys and Gamma-TiAl
2:00 pm	Volodymyr Filipov	Influence of Lattice Parameter Mismatch between Fibers and Matrix on Structure and Properties of Directionally Solidified LaB_6 - $(Ti,Zr)B_2$ Composites
2:30 pm		Break

Tuesday August 4, 2009 (continued)

Processing, Synthesis, and Structure (continued)

3:00 pm	Art Bronson and Jack Chessa	Computational Design of Ultrahigh Temperature Ceramics
3:30 pm	Valeriy Kartuzov	Pseudopotential Method of Calculation of Temperature of Formation and Eutectic Concentration in System LaB_6-MeB_2 (Me -Ti, Zr, Hf, Cr, V)
4:00 pm	Inna Talmy	Synthesis, Processing, and Properties of TaC-TaB_2-C Ceramics
4:30 pm	Bridget Rogers	Formation and Characterization of AlO_xC_y and HfO_xC_y
5:00 pm	Iegor Kartuzov	Estimation of Pulling Rate Interval in the Method of Directed Solidification of Fibrous Boride Composites
5:30 pm		Adjourn for the day

Wednesday, August 5, 2009

Oxidation and Environmental Response

Time	Speaker	Title
8:00 am	Frederic Monteverde	Plasma Wind Tunnel Testing and Numerical Simulation of Ultra-High Temperature Ceramics for Space Applications
8:30 am	Doug Fletcher	Status of the 30 kW Inductively Coupled Plasma Torch Facility at University of Vermont
9:00 am	Joe Marschall	Optical Diagnostics for UHTC Materials Characterization
9:30 am	Sylvia Johnson and Matt Gasch	Arcjet Oxidation and Mechanical Evaluation of Hafnium-Based Ultra-High Temperature Ceramics Fabricated by Hot Pressing and Field Assisted Sintering
10:00 am		Break
10:30 am	Robert Speyer	Oxidation Resistance of ZrB_2 with SiC, TaB_2, and $TaSi_2$ Additions up to 1800°C
11:00 am	Erica Corral	Processing and High Temperature Testing of ZrB_2-C-C Composites Coated with SiC
11:30 am	Xinghong Zhang	Preparation, Toughening/Strengthening and Oxidation of ZrB_2-Based Ultra-High Temperature Ceramic Composites
noon-1:45		Lunch on your own
1:45 pm		Transportation from hotel to Boeing (meet in lobby)
2:00 pm		Boeing Prologue Room reception/ Large Core Arc Tunnel tour
4:30 pm		Transportation back to Hotel
4:45 pm		Arrive at hotel and adjourn

Appendix C: Foreword for Journal of the European Ceramic Society

Guest Editorial

Joan Fuller, Greg Hilmas, William Fahrenholtz, Erica Corral, and Laura Riegel

The manuscripts in this issue are based on presentations at the Workshop on Aerospace Materials for Extreme Environments that was held August 3-5, 2009 in St. Louis, MO. This was the third in a series of workshops sponsored by the United States Air Force Office of Scientific Research.[1] The purpose of the workshop was to discuss the current status and latest technical progress of fundamental research on ultra-high temperature materials. The workshop featured invited speakers from academia, industry, and government laboratories from around the world. The agenda included 28 presentations and 23 posters that were focused on the basic science of processing, microstructure development, properties, and modeling of ultra-high temperature materials.

Ultra-high temperature materials have been categorized based on wide-ranging criteria such as melting temperature (>~3000° C), upper temperature limit for continuous use (>1600°C), or chemical family (refractory transition metals, carbon, plus carbides, borides, and nitrides of early transition metals). To be included in this workshop, materials had to be potential candidates for transition into future hypersonic air or space vehicles. Some of the likely applications for these ultra-high temperature materials include leading edges, acreage thermal protection systems, scramjet flow-path components, and rocket propulsion components.

Historically, ultra-high temperature materials were investigated in the U.S.S.R. and the U.S. from the late 1950s through the early 1970s as part of the original space race. Fundamental research on ultra-high temperature materials was largely dormant until a recent resurgence that began in the late 1990s. Since that time, research groups have been established in Italy, China, Ukraine, the U.S., and other countries. As an indication of the increase in the level of research worldwide, data available on Scopus indicates that publications on the topic of "ultra-high temperature ceramics" increased from ~5 in 2000 to 74 in 2008 while published papers on the compound zirconium diboride increased from ~80 in 2000 to more than 200 in 2008.

The Workshop on Aerospace Materials for Extreme Environments included sessions on "Mechanical and Physical Properties," "Processing, Synthesis and Structure," and "Oxidation and Environmental Response." Some of the significant accomplishments that are reported in the manuscripts in this issue include in-situ measurement of mechanical properties at temperatures above 2000°C, a crystal chemical approach to synthesis of ultra-refractory ternary carbides, and diagnostics for material behavior in plasma environments similar to those encountered in hypersonic flight and/or atmospheric re-entry. Taken together, the manuscripts and presentations point to the tremendous challenge associated with modeling, predicting, and controlling the behavior of structures with complex, hierarchical, and/or engineered architectures that are composed of materials with dissimilar physical and chemical properties.

Despite the significant progress reported in the manuscripts in this issue, discussions at the workshop pointed to several outstanding areas where additional research efforts are needed. In particular, research is needed to understand coupled thermal and mechanical behavior including the development of methods to monitor and predict highly correlated properties in extreme environments. Novel compositions and chemistries are also relatively underreported and new compositions with microstructures tailored for improved elevated temperature strength and creep resistance in addition to improved resistance to oxidation would greatly enhance future capabilities. Hopefully, future workshops will report on progress made in these and other areas.

---

[1]. Manuscripts from the other two workshops were published in the Journal of Materials Science, 39(19), October 2004 and the Journal of the American Ceramic Society, 91(5), May 2008.

Appendix D: List of Manuscripts Submitted for Publication

Contact	Author	Authors and Title
Donna	Ballard	D.L. Ballard, D.S. Weaver, A.L. Pilchak and S.L. Semiatin, "Hot Working of Platinum Group Metal-Modified Ni-Base Superalloys"
Arturo	Bronson	H. Petla, E. Renova, A. Bronson, J. Chessa and N. Maheshwaraiah, "A Computational Analysis of a ZrO_2-SiO_2 Scale for a ZrB_2-ZrC-Zr System as an Ultrahigh Temperature Ceramic Composite"
Erica	Corral	E.L. Corral and L.S. Walker, "Inhibition of C-C Composites Using Zirconium Diboride and Boron Carbide"
Matt	Gasch	M. Gasch and S. Johnson, "Physical Characterization and Arcjet Oxidation of Hafnium-Based Ultra High Temperature Ceramics Fabricated by Hot Pressing and Field Assisted Sintering"
Oleg	Grygoriev	O. Grigoriev, B. Galanov, V. Lavrenko, A. Panasyuk, V. Kotenko, S. Ivanov, A. Koroteev, and K. Nikel, "Sintering and Microstructure of ZrB_2-SiC($ZrSi_2$) System"
John	Halloran	S. Gangireddy, J. Halloran, and Z. Wing, "Non-Contact Mechanical Properties of UHTC at Ultrahigh Temperatures Using Lorentz Forces on Electrically Heated Ribbons"
John	Halloran	S. Gangireddy, S. Karlsdottir, and J. Halloran, "In Situ Optical Microscopy During High Temperature Oxidation of Zirconium Diboride- Silicon Carbide Ultra High Temperature Ceramic Composites, Part 1: Liquid Flow and the Growth of Zirconia Deposits"
John	Halloran	S. Gangireddy, J. Tucker, S. Norton, and J. Halloran, "In Situ Optical Microscopy During High Temperature Oxidation of Zirconium Diboride- Silicon Carbide Ultra High Temperature Ceramic Composites: Part 2- Formation of Carbon Monoxide Bubbles"
Greg	Hilmas	J. Watts, G. Hilmas, W. Fahrenholtz, D. Brown, and B. Clausen, "Stress Measurements in ZrB_2-SiC Composites Using Raman Spectroscopy and Neutron Diffraction"
Greg	Hilmas	M.C. Teague, G.E. Hilmas, W.G. Fahrenholtz, "Mechanical Properties of Reactively Processed W/Ta_2C-Based Composites"
Robert	Hyers	X. Ye and R.W. Hyers, "Computational Simulation of Non-contact Creep Deformation of ZrB_2/ZrB_2+SiC"
Sergey	Ivanov	O.N. Grigoriev, B.A. Galanov, V.A. Lavrenko, A.D. Panasyuk, S.M. Ivanov, A.V. Koroteev, and K.G. Nikel, "High-Temperature Oxidation of ZrB_2-SiC-$ZrSi_2$ Ceramics in Oxygen"
Valery	Kotenko	V. Kotenko, O. Grygoriev, B. Galanov, and S. Ivanov, "New Methods for the Strength Properties Determination of Brittle Materials"
Trudy	Kriven	P. Sarin, P. Driemeyer, R. P. Haggerty, D.-K. Kim, J. L. Bell, and W. M. Kriven, "In-Situ Studies of Oxidation of ZrB2 and ZrB2-SiC Composites at High Temperatures"
William	Lee	D.D. Jayaseelan, H. Jackson, E. Eakins, P. Brown and W.E. Lee, "Laser Modified Microstructures in ZrB2, ZrB2/SiC and ZrC"
Jochen	Marschall	T.H. Squire and J. Marschall, "Material Property Requirements for Analysis and Design of UHTC Components in Hypersonic Applications"
Jochen	Marschall	J. Marschall and D.G. Fletcher, "High-Enthalpy Test Environments, Flow Modeling and In Situ Diagnostics for Characterizing Ultra High Temperature Ceramics"
Frederic	Monteverde	F. Monteverde, R. Savino, M. Fumo, and A. Mas, "Plasma Wind Tunnel Testing of Ultra-High Temperature ZrB_2-SiC Composites under Hypersonic Re-entry Conditions"
Greg	Morscher	G. Morscher, "Tensile Creep and Rupture of 2D Woven SiC/SiC composites for High Temperature Applications"

List continued on next page

List of submitted manuscripts (continued)

Contact	Author	Authors and Title
Dusan	Pejakovic	D. Pejakovic, J. Marschall, M. George, B. Rogers, W. Nieveen, and V. Pajcini, "Synthesis of Carbon-Rich Hafnia Thin Films by Pulsed Laser Deposition"
Rishi	Raj	K. Terauds, P. E. Jimenez–Sanchez, R. Raj, C. Vakifahmetoglu and P. Colombo , "Giant Piezoresistivity of Polymer-Derived Ceramics at High Temperatures"
Bridget	Rogers	B.W. Schmid, B.R. Rogers, W.J. Sweet, III, C.K. Gren, T.P. Hanusa, "Deposition of Alumina From Dimethylaluminum Isopropoxide"
Ken	Sandhage	D. Lipke, Y. Zhang, Y. Liu, B. Church, and K. Sandhage, "Near Net-Shape/Net-Dimension ZrC/W-Based Composites with Complex Geometries Via Rapid Prototyping and Displacive Compensation of Porosity"
Luigi	Scatteia	D. Alfano, L. Scatteia, F. Monteverde, E. Bêche, and M. Balat-Pichelin, "Micro-structural Characterization of ZrB_2-SiC based UHTC Tested in the MESOX Plasma Facility"
Laura	Silvestroni	L. Silvestroni, D. Sciti, C. Melandri, and S. Guicciardi, "Toughened ZrB2-Based Ceramics through SiC Whiskers or SiC Chopped Fibers Addition"
Inna	Talmy	I.G. Talmy, J.A. Zaykoski, and M.M. Opeka, "Synthesis, Processing and Properties of TaC – TaB_2 – C Ceramics"
Vikas	Tomar	V. Tomar, "Atomistic Analyses of the Effect of Temperature and Morphology on Mechanical Strength of Si-C-N and Si-C-O Nanocomposites"
Guo-Jun	Zhang	W.-M. Guo and G.-J. Zhang, "Oxidation Resistance Evaluation and Strength Retention of ZrB_2-SiC Ceramics"
Xinghong	Zhang	P. Hua, X. Zhang, and G. Wang, "High-Temperature Strength of ZrB_2-SiC Composites"
Yanchun	Zhou	L. Hea, F. Lia, X. Lua, and Y. Zhou, "Microstructure,Thermal and Mechanical Properties of a $Zr_2[Al(Si)]_4C_5$-SiC Composite Prepared by In Situ Reaction/Hot-Pressing Method"